MULTI-CHARACTER DISPLAY DRIVERS SIMPLIFY DISPLAY DESIGN AND ARE EASILY INTEGRATED INTO COMPUTER BASED SYSTEMS.

by DAN WATSON, INTERSIL INC.

Decoding and driving circuits for various types of numeric and alphanumeric displays have been greatly simplified by large scale integration. These new display drivers dramatically exhibit the following benefits and advantages over discrete designs:

- more circuit functions in less space
- simpler design effort for the user
- more flexible operation
- reduced circuit expense

Consider, for example, the design of an ASCII eight character alphanumeric multiplexed LED display system. The block diagram for such a system constructed with discrete and MSI components is shown in figure 1. Included as one of the blocks is an eight word by six bit memory which stores the six bit ASCII word for each of the characters to be displayed. The addresses for the memory are selected either from the input circuitry when writing to the disolay or from the three bit counter which generates the addresses for the three line to eight line decoder. The NPN transistors drive the common cathode display for each character. The data from the memory is sent to a decoder which determines the correct segments to be turned on and would have to be a specially programmed ROM or PLA with one output for each of the 14 or 16 segments in the character. The PNP transistors serve as individual segment drivers and the resistors in each of their collectors serve to set the current for that segment.

FIGURE 1. EIGHT CHARACTER ALPHANUMERIC LED DISPLAY SYSTEM (DISCRETE DESIGN)

By contrast, figure 2 shows an ASCII eight-character alphanumeric multiplexed LED display system in which all of the decoding, multiplexing, and driving is accomplished by a single integrated circuit, Intersil's ICM7243. The savings in board space, design time by the user, and cost are easy to see. Additionally, this single chip approach will have several features such as microprocessor compatibility, low power shutdown mode, and automatic interdigit blanking built in. These features would require extra circuitry in the discrete design and increase the cost of the system.

FIGURE 2. EIGHT CHARACTER ALPHANUMERIC DISPLAY SYSTEM SINGLE CHIP DESIGN)

The integrated circuits now available provide a wide selection of display driving capability and can be divided into several categories. Most numeric display drivers also provide a few alphabetic characters for displaying hexadecimal values. True alphanumeric display devices have numbers, letters, punctuation marks, and other symbols in their character sets. The interconnection to display driver ICs also varies from multiplexed BCD inputs to serial bit-stream arrangements or parallel microprocessor bus compatible input schemes.

NON-MULTIPLEXED DISPLAYS

Intersil offers a family of four-digit numeric display drivers that directly drive the display elements without multiplexing. In this case direct drive means that there is one line for each segment of the display (four digits times seven segments = 28 lines). The ICM7211 drives liquid crystal displays (LCD), the ICM7212 drives light emitting diode displays (LED), and the ICM7235 drives vacuum fluorescent display panels (VF). The segment driver outputs of the ICM7235 can handle up to 30 volts when off, which is more than adequate for most vacuum fluorescent displays. Since the display outputs are not multiplexed, the power supply current in the LED and VF devices will only change when the digits being displayed change. This is in contrast to multiplexed displays where the power supply current changes radically at the multiplex rate. These three display drivers are identical except for the output driver structure. Multiplexed BCD or microprocessor bus compatible input configurations are available. Intersil's ICL7135 4 1/2 digit A/D converter, and many other devices and systems, outputs the data in the multiplexed BCD format which is directly compatible with this line of display drivers. The standard character sets of these devices are shown in table 1. Any other combination of seven-segment characters can be mask programmed.

TABLE 1. HEXADECIMAL AND CODE-B CHARACTER SETS

Figure 3 shows a pair of ICM7211M devices set up on an 8048 bus and accessed by port lines to form an eight digit LCD display for a microcomputer based system. In this arrangement any digit can be changed independantly from the rest and the display used for system values in decimal or hexadecimal notation. The lines B0-B3 are the data input lines of the display drivers. The data on these lines is decoded from BCD to seven segment format when the chip select (CS1 and CS2) conditions are met for that device. The digit to be written is determined by the digit select lines, DS1 and DS2. The 56 segment drive lines from the two ICM7211s are synchronized by use of the OSC INPUT (pin 36) on the right-hand ICM7211. When this pin is tied high, the backplane output (pin 5) is transformed into an input and can be driven by the backplane output of the left-hand ICM7211. In this way a single eight digit LCD display with one backplane connection can be driven by two LCD display drivers.

FIGURE 3. EIGHT DIGIT LCD MICROCOMPUTER DISPLAY

The ICM7211, 7212, and 7235 display drivers are directly related to a family of counter/display drivers, ICM7224, 7225, and 7236. These devices are 4 1/2 digit counters that directly drive LCD, LED or VF displays. They are capable of counting at a 25MHz rate, displaying results up to 19999, and are easily cascadable to form higher resolution counters. Evaluation kits for these counters, display drivers, and the ICL7135 A/D converter are available from Intersil.

MULTIPLEXED DISPLAYS

Intersil's ICM7218 family of eight-digit multiplexed LED numeric display drivers is more versatile and require fewer interconnect lines than non-multiplexed display drivers. The A, C, and E suffix devices will drive common-anode LED displays while the B and D suffix devices will drive common-cathode LED displays. All have selectable character sets (hexadecimal or code B as in table 1), shutdown mode, and decimal point inputs and outputs. The ICM7218C, D, and E are capable of independantly addressing any of the eight digits witout changing the others. The ICM7218A and B address the digits sequentially when written to by external circuitry.

A 16 digit microprocessor display application is shown in figure 4 using two ICM7218C devices connected to the data and address lines of an 8048 microcomputer. Note that the individual seven segment displays are interleaved to simplify the addressing of the two driver chips. The three digit address lines of each ICM7218 are tied to the same three address lines of the 8048. When data appears on the data output lines of the 8048 and the write command is given the display drivers will be addressed simultaneously and the two digits addressed by DA0, DA1, and DA2 will be written simultaneously. The decimal point inputs come from the 8048 address lines. The code selected by pin 9 of the ICM7218 is hexadecimal.

FIGURE 4. 16 DIGIT LED MICROCOMPUTER DISPLAY

Independant addressing and the no-decode mode of the ICM7218A, B, and E allow them to be used in non-numeric applications. Since each LED segment is independantly addressable by way of eight data input lines and eight segments per digit (7 + decimal point), it is possible to use them as LED system status panel drivers or as 64 segment bar graph drivers. Two LED system status panel examples are shown in figure 5, one with 32 channels of red and green LEDs, and one with 21 channels of red, yellow, and green LEDs. Both of these status panels can be driven by one ICM7218 display driver with individual LEDs arranged in groups of eight for each of the eight digit drive outputs.

FIGURE 5 STATUS PANEL EXAMPLES FOR ICM7218

Figure 6 shows a block diagram of an ICM7218E used in a six-bit binary to 64-segment bar graph application. The write control block generates the write command and address of the group of eight segments to be written. The address is compared with the three MSBs of the input binary value. If the address to be written is less than the three MSBs, then the data is to be all 'ones', turning on those eight segments coorsponding to the three MSBs. If the address is greater than the three MSBs, the data is to be all 'zeroes'. When the address is equal to the three MSBs the data generator uses the three LSBs of the input word to determine the point at which the bar graph changes from on to off. The data is found by:

$$\text{data value} = (2^{N}) - 1$$

where N is the three bit LSB value (0 to 8)

Note that the data sent to the decimal point input (pin 8) needs to be inverted.

FIGURE 6. SIX-BIT BINARY TO BAR GRAPH APPLICATION

Alphanumeric LED display systems have recently been simplified in the same way that the numeric-only LED display system has been simplified by the the ICM7218 family (figure 1 and 2). A pair of integrated circuits dedicated to 14 and 16 segment alphanumeric LED displays has been developed - the ICM7243A and B. These devices accept a six-bit parallel ASCII code, decode it, and drive the appropriate segments of an eight character common-cathode display. Figure 7 is the block diagram of the ICM7243. The mask programmable character sets and coorresponding ASCII codes are shown in table 2 for the 14 and 16 segment versions.

FIGURE 7. ICM7243 BLOCK DIAGRAM
TABLE 2. ASCII CHARACTER SETS FOR ICM7243

The ICM7243 has two input data modes. The Random Access (RA) mode allows independant addressing of characters by way of three digit address lines. The RA mode writes only the character addressed. The Serial Access (SA) mode writes characters from left to right on the display without having to externally address each character. Right to left writing can be done by wiring the digits in reverse order. The OSC/$\overline{\text{OFF}}$ pin on the ICM7243 provides a shutdown mode which, when grounded, will put the display driver in a low-power mode, blanking the displays while the memory section is kept active. The DISPLAY FULL and SERIAL ENABLE lines combine to make cascading display drivers easy. An example of a 24-character LED display is shown in figure 8. The MODE lines are all tied high to set up serial input and DISPLAY FULL is connected to SEN of the next device to enable cascading. When CHIP SELECT is high, The WRITE line is active-low. If, however, active-high is desired, WRITE can be tied low and CHIP SELECT used as an active-high write line. The characters will be written from left to right as new ASCII data is presented to the six-bit input bus and the WRITE command is given.

FIGURE 8. 24 CHARACTER ALPHANUMERIC LED MICROCOMPUTER DISPLAY

Figure 9 shows the use of the OSC/$\overline{\text{OFF}}$ pin to get into the shutdown mode. In this example two ICM7243s are dedicated to the same eight characters of the LED display. The drivers are enabled alternately performing a message select function. When the OSC/$\overline{\text{OFF}}$ pin is brought low by the open-collector inverter all outputs of that driver are turned off freeing its group of eight LED characters to be driven by the other ICM7243. The display driver is turned on by allowing the OSC/OFF pin to float.

FIGURE 9. ICM7243 MESSAGE SELECT APPLICATION

The average segment current of the ICM7243 is three milliamperes maximum (24 milliamps / 8 digits). This is quite enough current to give good contrast to the 0.375 or 0.4 inch high displays. If larger displays are to be driven it is an easy task to connect a simple transistor current boost circuit to each character and segment output. The current boost circuit shown in figure 10 will provide an average segment current of about 12 milliamps. This current should be sufficient to drive larger alphanumeric LED displays now available.

FIGURE 10. DISPLAY CURRENT BOOST CIRCUIT FOR ICM7243

TRIPLEXED LIQUID CRYSTAL DISPLAYS

Triplexing is a fairly new technique for multiplexing liquid crystal displays. This technique requires fewer lines to the display than the direct driving method described previously. Triplexed displays have a row-column organization with rows being three separate backplanes oriented horizontally across the display. The columns of the display are groups of three segments connected to the same input line. Figure 11 shows details of character layout and six-bit ASCII character set for numeric and alphanumeric triplexed LCD displays.

A segment is turned on when enough AC voltage is applied between the row and column (backplane and segment group) corresponding to that segment. To keep a segment turned off the voltages between the row and column for that segment must be less than the threshold for the display. In other words, if the AC voltages on the row and column corresponding to a given segment are large enough and out of phase, that segment will be on. If the voltages are less than the display threshold or are in phase then the segment will be off. The switching problems with this type of display driving technique are complex because the proper phase and voltage relationships must be maintained for each segment of the display in order to keep the display readable.

Fortunately, the solution to all of these problems need only be found once and then only by the engineer designing triplexed display drivers. The user need only find the right display driver IC and hook it up.

FIGURE 11. TRIPLEXED LCD CHARARACTER LAYOUT AND ASCII CHARACTER SET

A family of four triplexed LCD display drivers are available now in numeric or alphanumeric form with parallel or serial input structure. The ICM7231 and ICM7232 are numeric devices that drive eight and ten digits plus two annunciators per digit. The ICM7233 and ICM7234 are alphanumeric devices that drive four and five 16-segment characters plus two annunciators per character. Parallel input structure is found on the ICM7231 and 7233 while the ICM7232 and 7234 have serial input structure.

ICM7231 and ICM7234 are shown in figure 12. The ICM 7232 has serial input and drives 10 digits and the ICM 7233 has parallel inputs and drives four characters. The advantages of this type of display system are:

-very low power consumption
-capable of driving large-size displays
-no external decoding required
-direct connection to microprocessors
-serial input accomodates remote displays.
-minimum number of lines to the display

FIGURE 12. ICM7231 AND ICM7234 BLOCK DIAGRAM

Figure 13 shows an 8048 microcomputer with an eight-digit triplexed LCD display accessable BY port lines. Four of the eight lines on the data bus are for data, three for digit address, and one for anunciator or decimal point. The display is written when the write command is given to that port and the entire display can be written by outputting eight bytes. Temperature compensation for the display is done by the resistor-transistor network connected to the VDISP pin of the ICM7231. Two other temperature coeficient correcting circuits are shown in figure 14.

-FIGURE 13. EIGHT DIGIT TRIPLEXED LCD MICROCOMPUTER DISPLAY
FIGURE 14. TRIPLEXED LCD TEMPCO COMPENSATION CIRCUITS

An example of the serial interface connection can be seen in figure 15 where a COPS420C microcomputer has been fitted with a 10-character alphanumeric LCD display. The display and drivers can easily be located at some remote point in the system and communicate with the microcomputer via the four data lines, serial data, serial clock, WRITE1, and WRITE2.

The microcomputer controls which character is being written by sending the appropriate write pulse and by sending the digit address bits. The last three bits in the string of nine sent to the ICM7234s are the digit address bits. Since the digit addressing is sent with each data word, the display may be written in random access mode.

FIGURE 15. 10 CHARACTER ALPHANUMERIC TRIPLEXED LCD DISPLAY WITH SERIAL MICROCOMPUTER INTERFACE

The display drivers mentioned here are examples of how CMOS technology is being used to simplify the design of numeric and alphanumeric display systems for the user. The method of driving (direct, multiplex, triplex) is not usually as important to a system designer as the questions regarding what type of display (LCD, LED, Vacuum Fluorescent, Gas Discharge), what size of display, and how many digits or characters should be displayed. The actual construction of display systems is easier now that there is a wide selection of decoder/drivers to choose from.

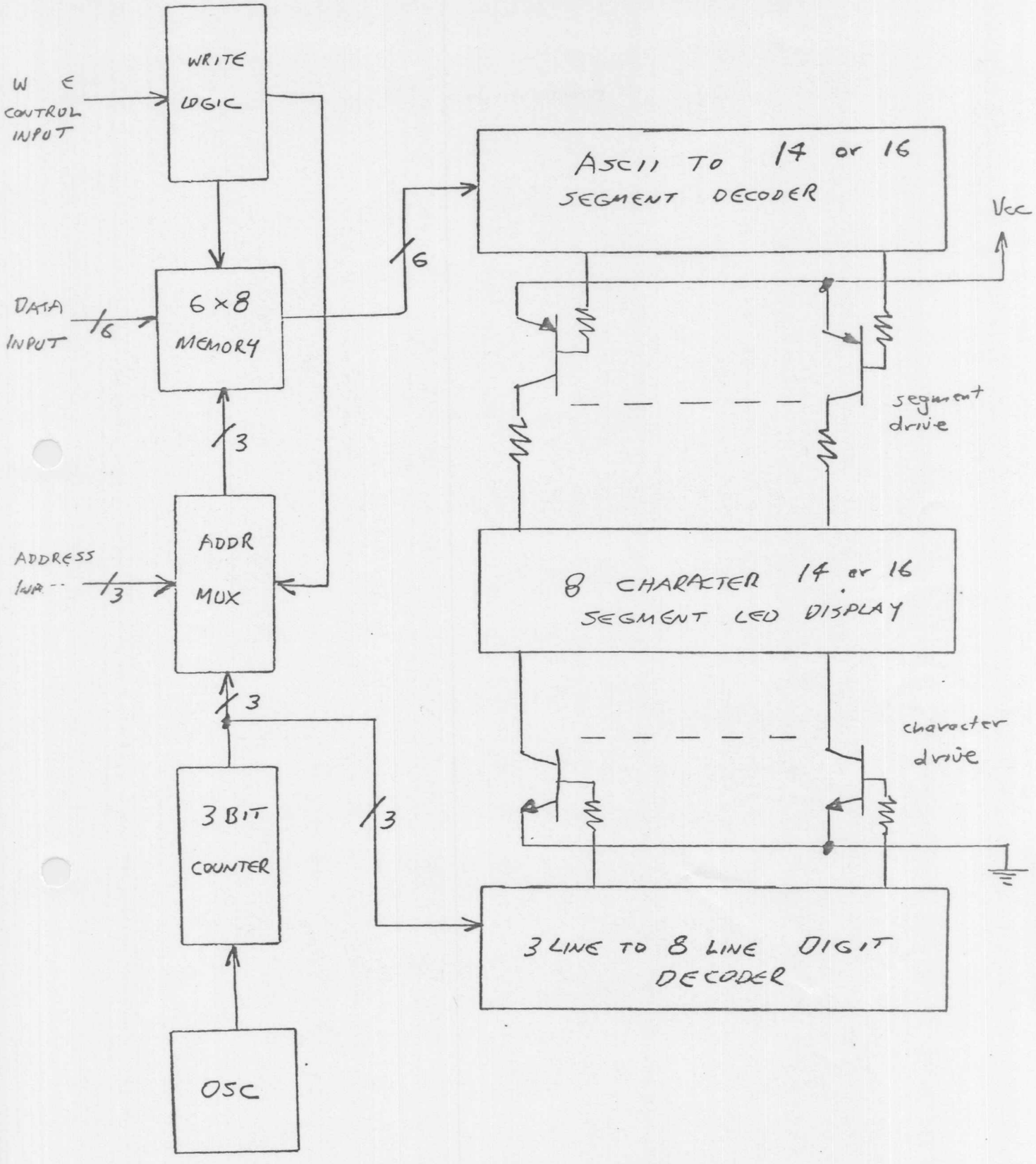


FIGURE 1 EIGHT CHARACTER ALPHANUMERIC LED DISPLAY SYSTEM (DISCRETE DESIGN)

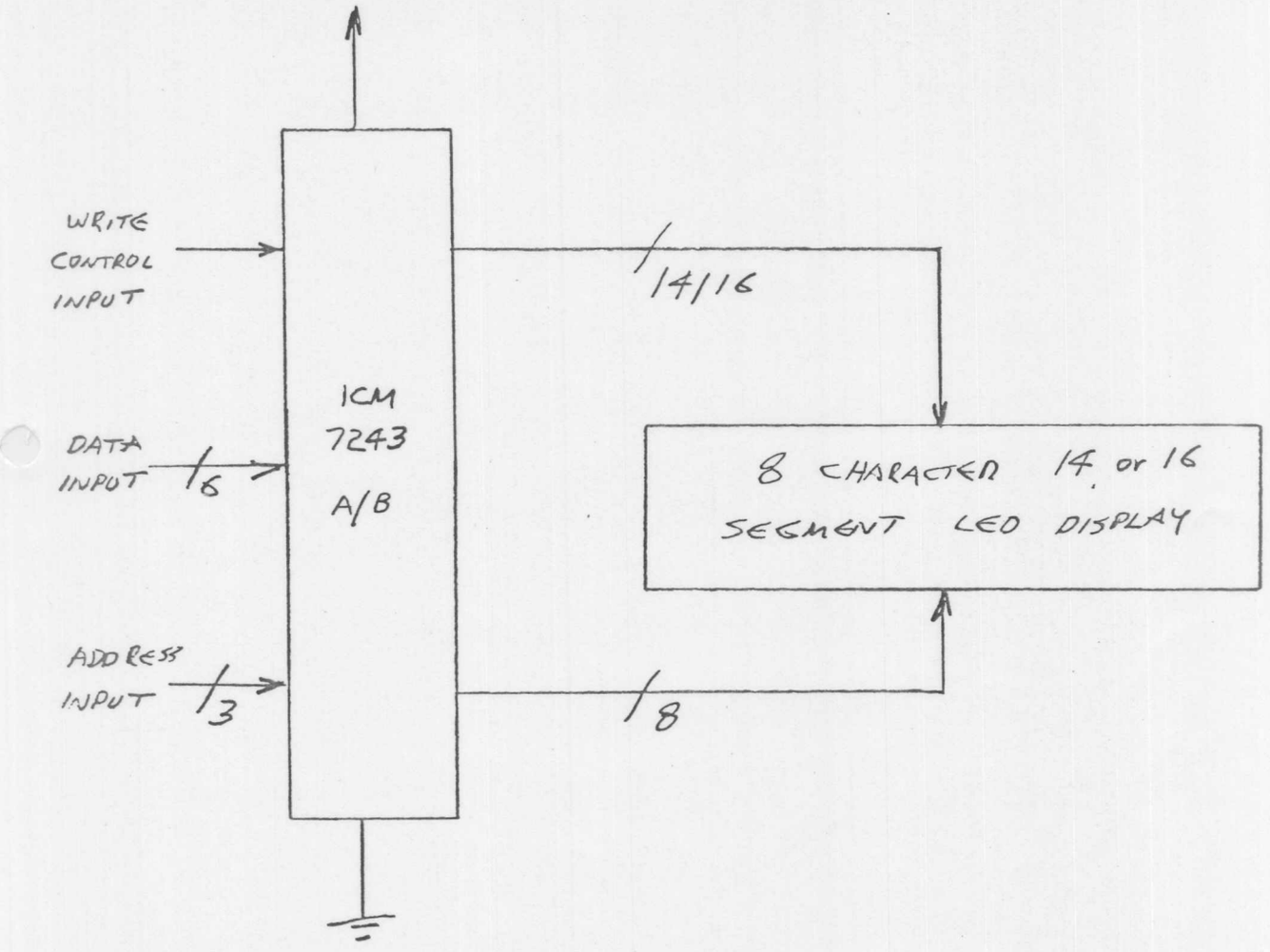


FIGURE 2 EIGHT CHARACTER ALPHANUMERIC LED DISPLAY SYSTEM (SINGLE CHIP DESIGN)

Binary Code	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hexa Code	0	1	2	3	4	5	6	7	8	9	A	b	C	d	E	F
Code B	0	1	2	3	4	5	6	7	8	9	-	E	H	L	P	(Blank)

TABLE 1 HEXADECIMAL AND CODE-B CHARACTER SETS

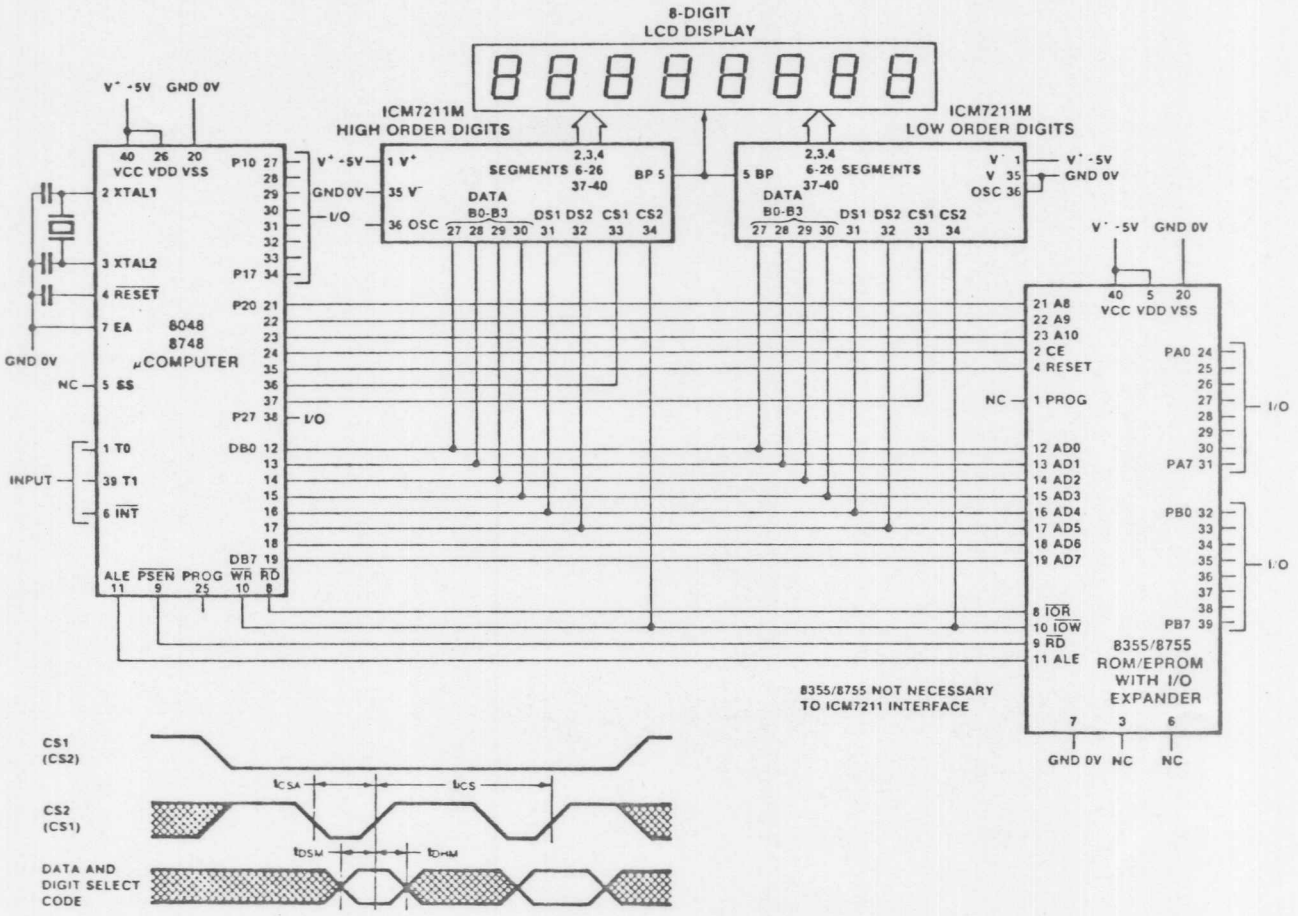


FIGURE 3 EIGHT DIGIT LCD MICROCOMPUTER DISPLAY

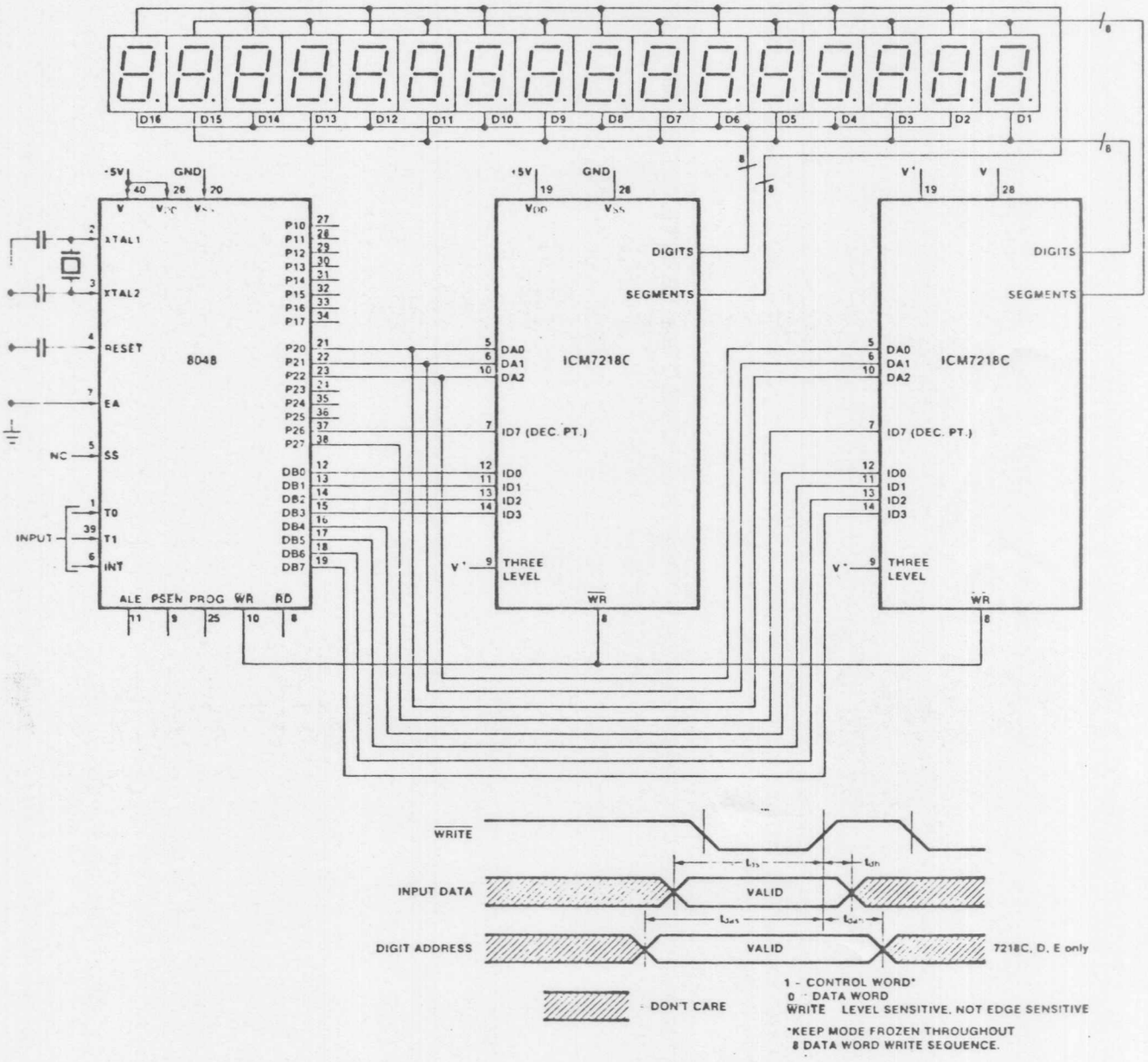
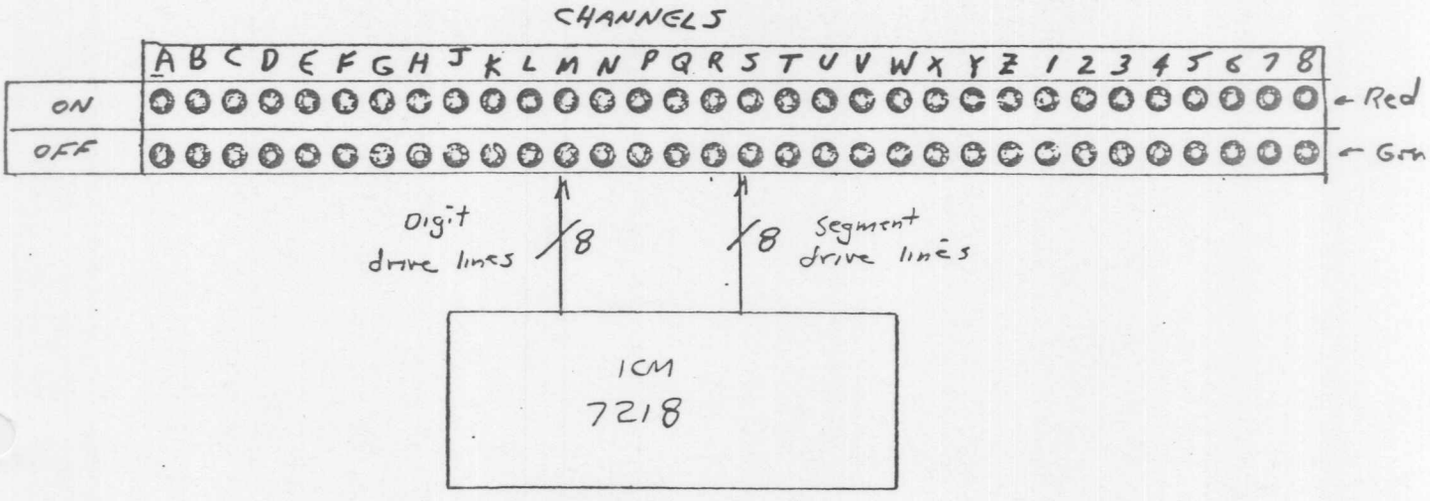
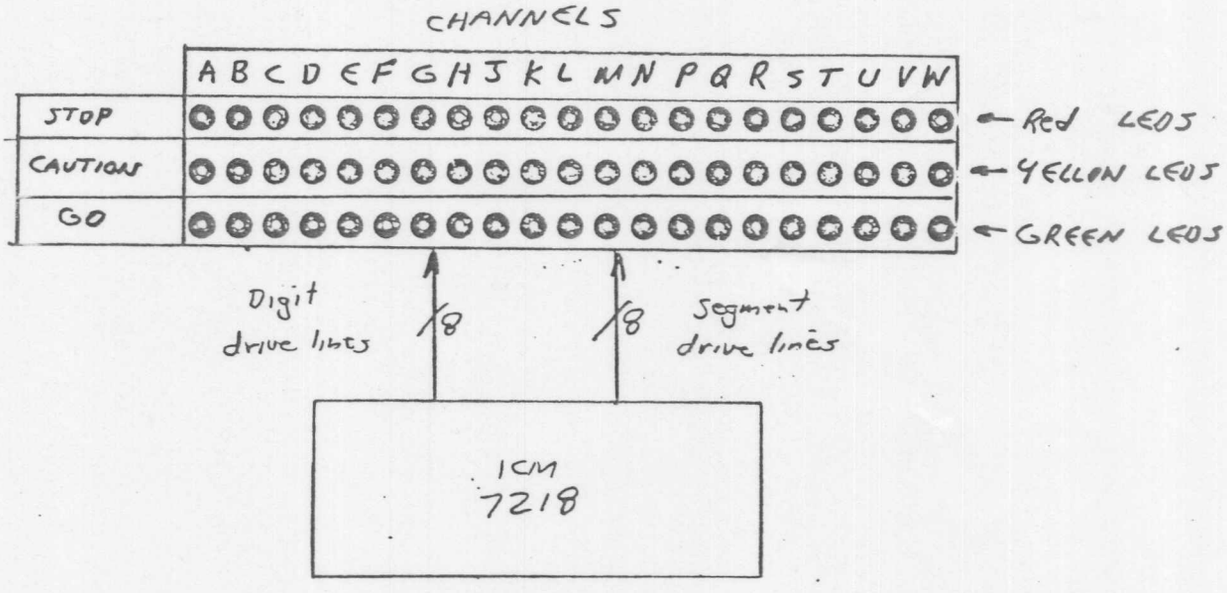


FIGURE 4 16 DIGIT LED MICROCOMPUTER DISPLAY

FIGURE 5 STATUS PANEL EXAMPLES FOR ICM7218



32 Channel x 2 Indicators Status Panel



21 Channel x 3 Indicator Status Panel

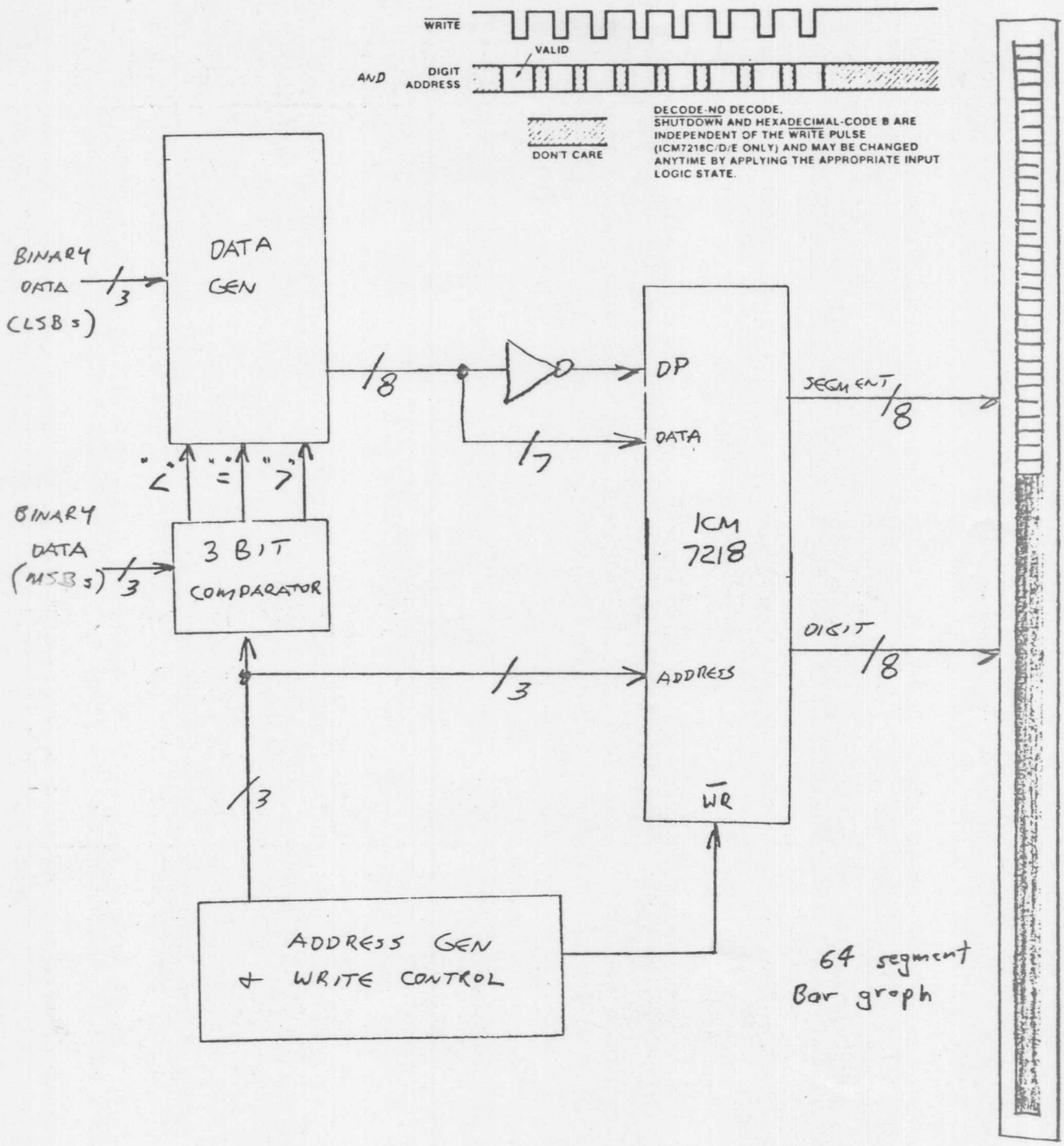
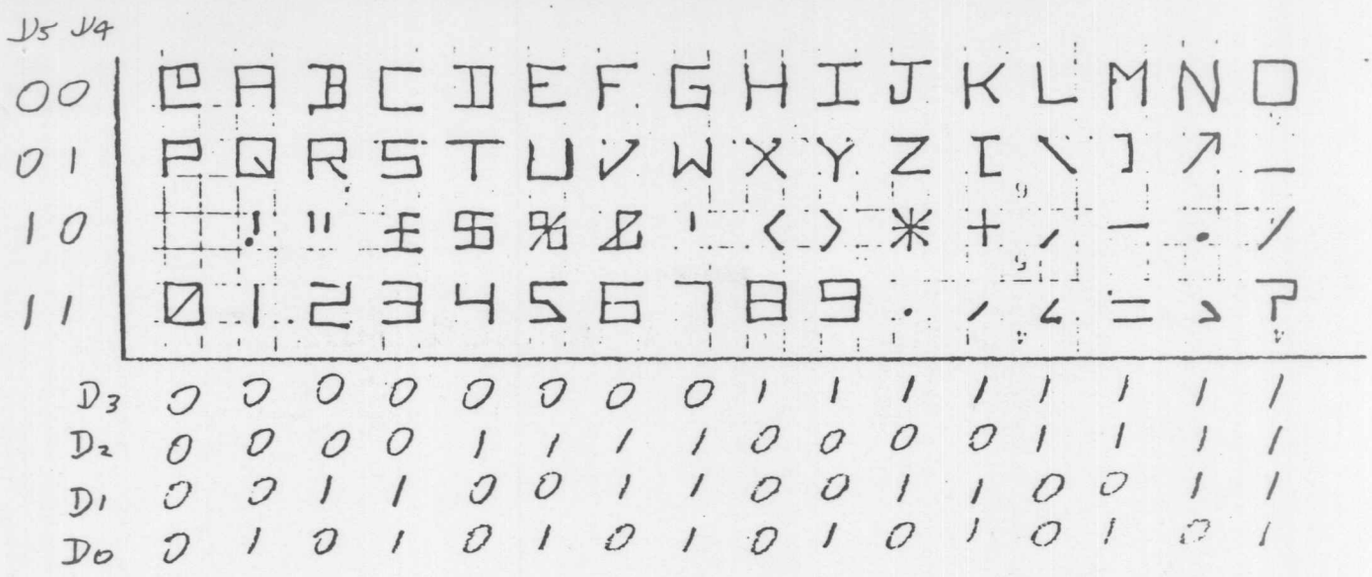
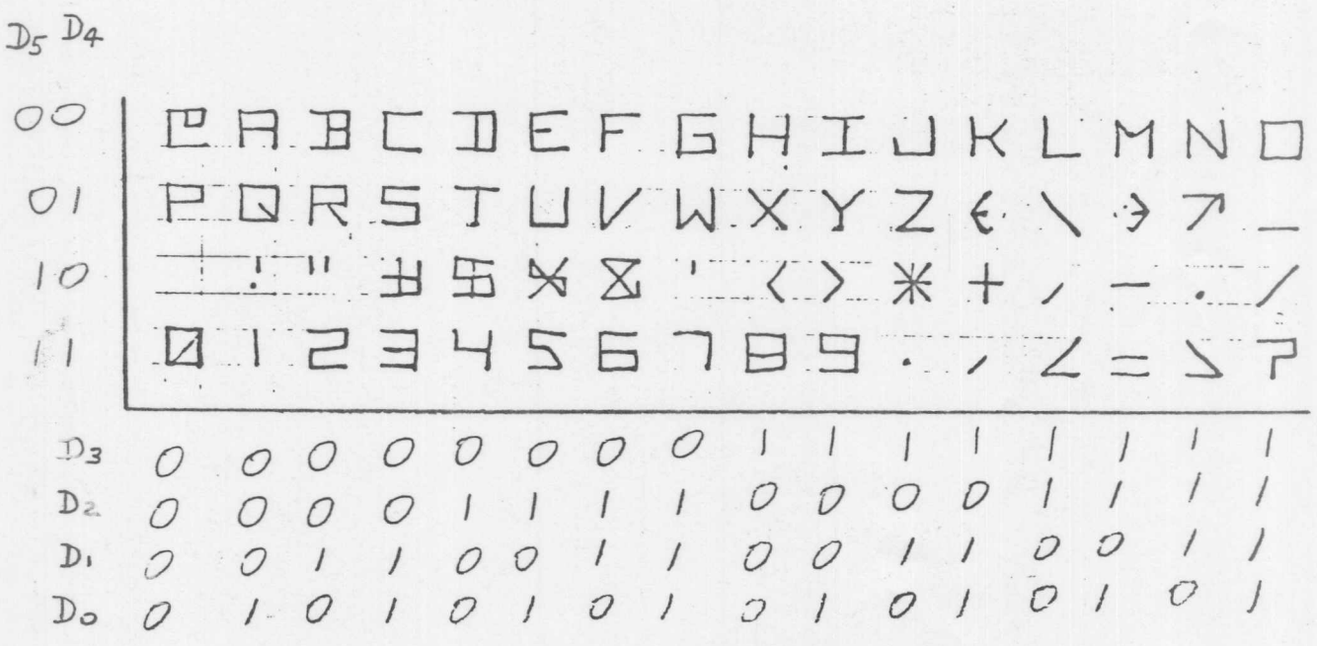


FIGURE 6 SIX-BIT BINARY TO BAR GRAPH APPLICATION



ICM7243A
(16 segment characters)



ICM7243B
(14 segment characters)

TABLE 2 ASCII CHARACTER SET FOR ICM7243

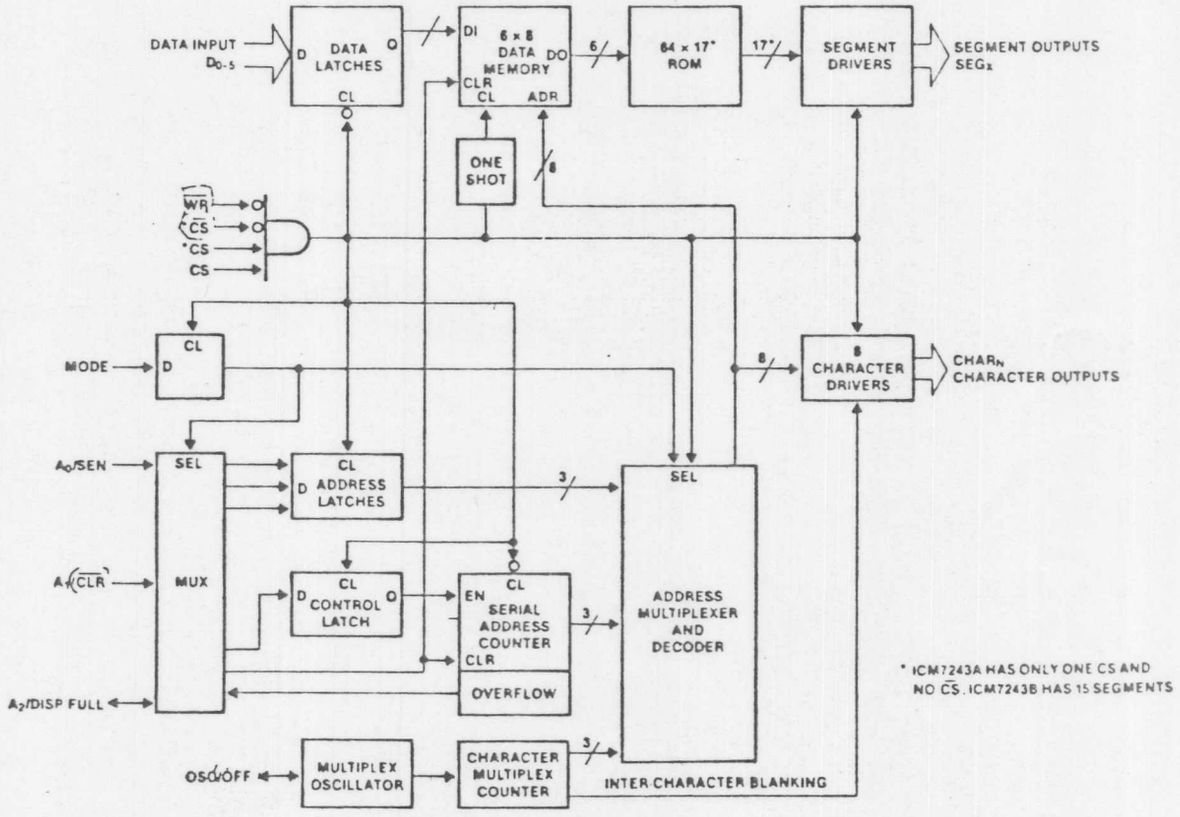


FIGURE 7 ICM7243 BLOCK DIAGRAM

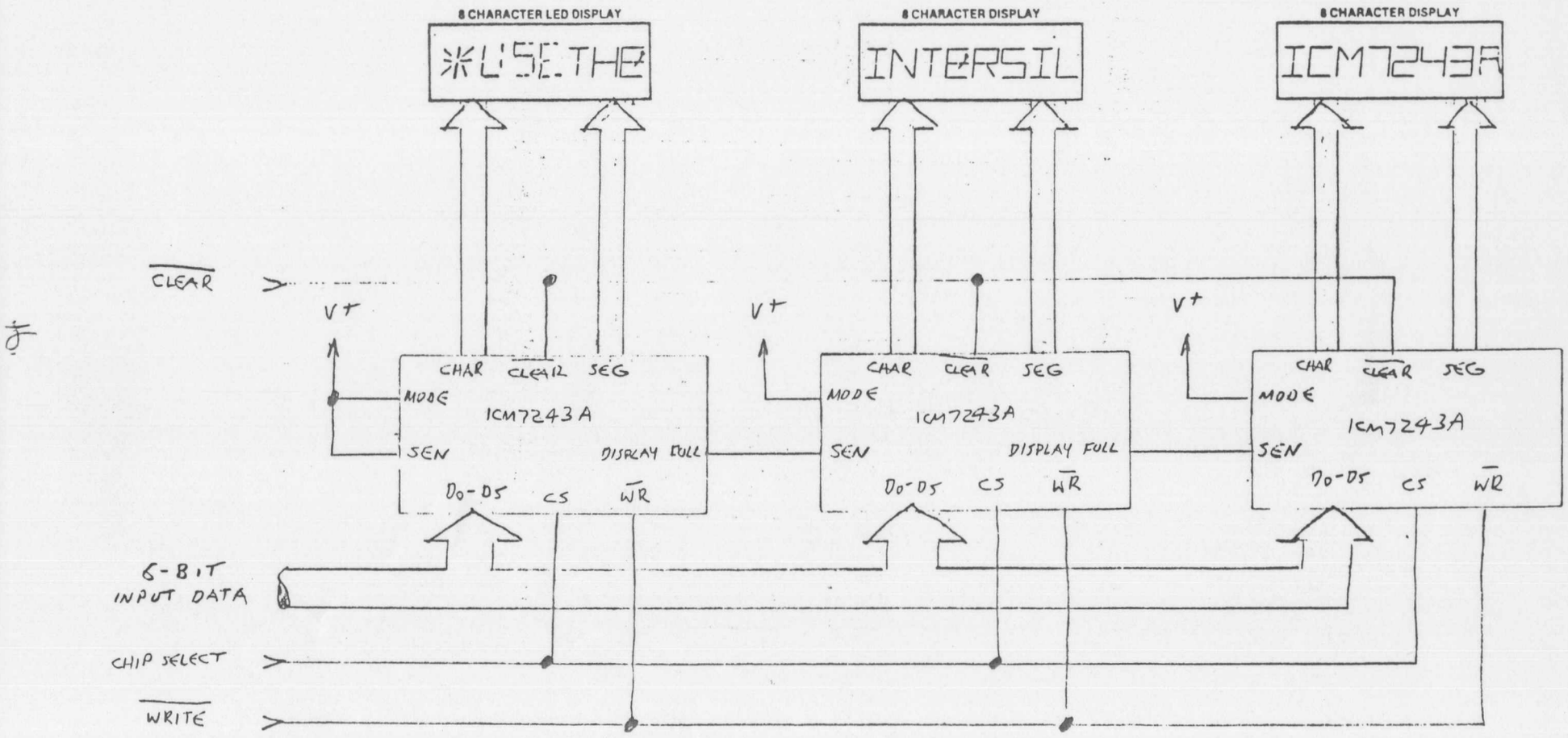
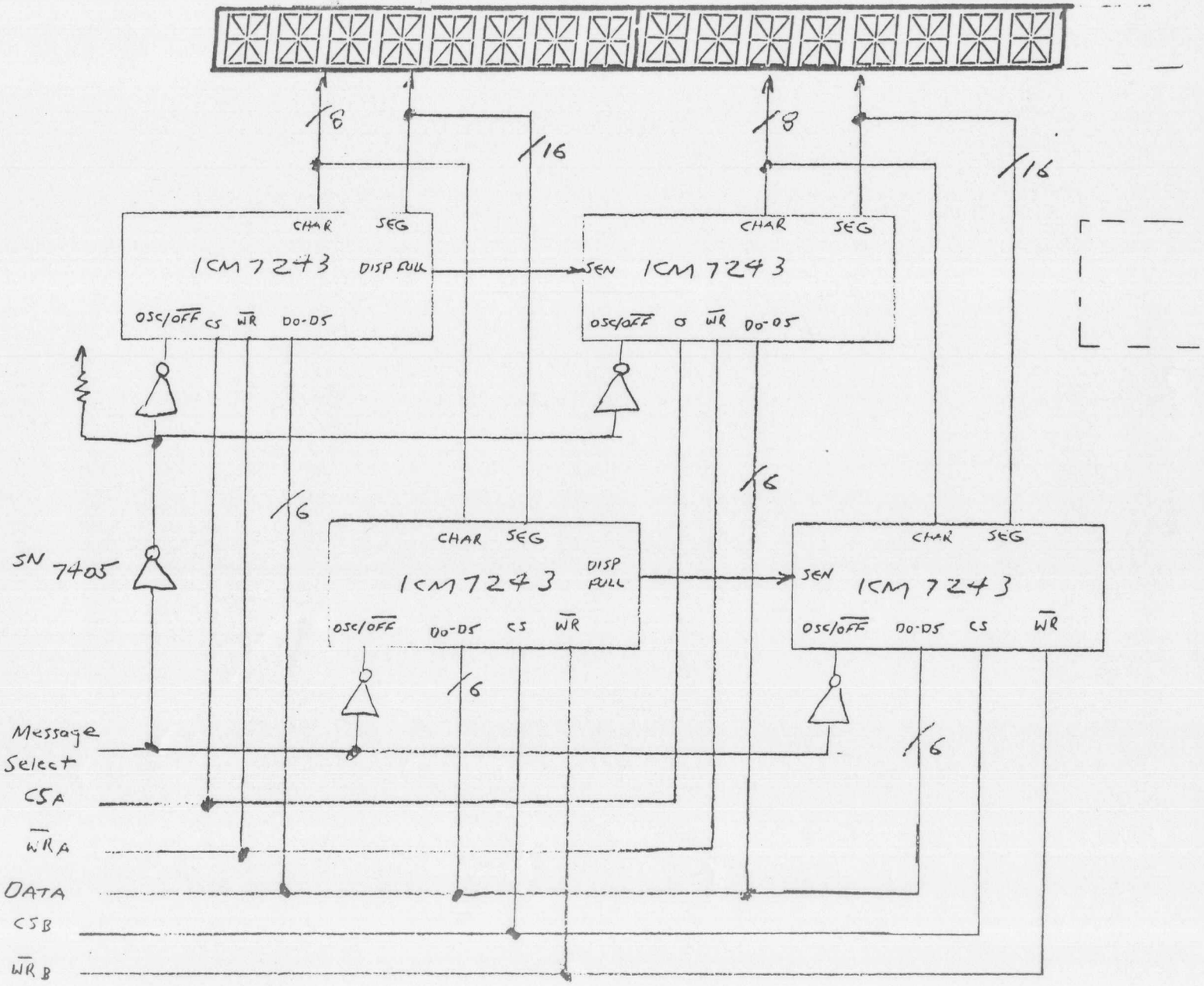


FIGURE 8 24 CHARACTER LED MICROCOMPUTER DISPLAY

FIGURE 9 ICM7243 ME .AGE SELECT APPLICATION



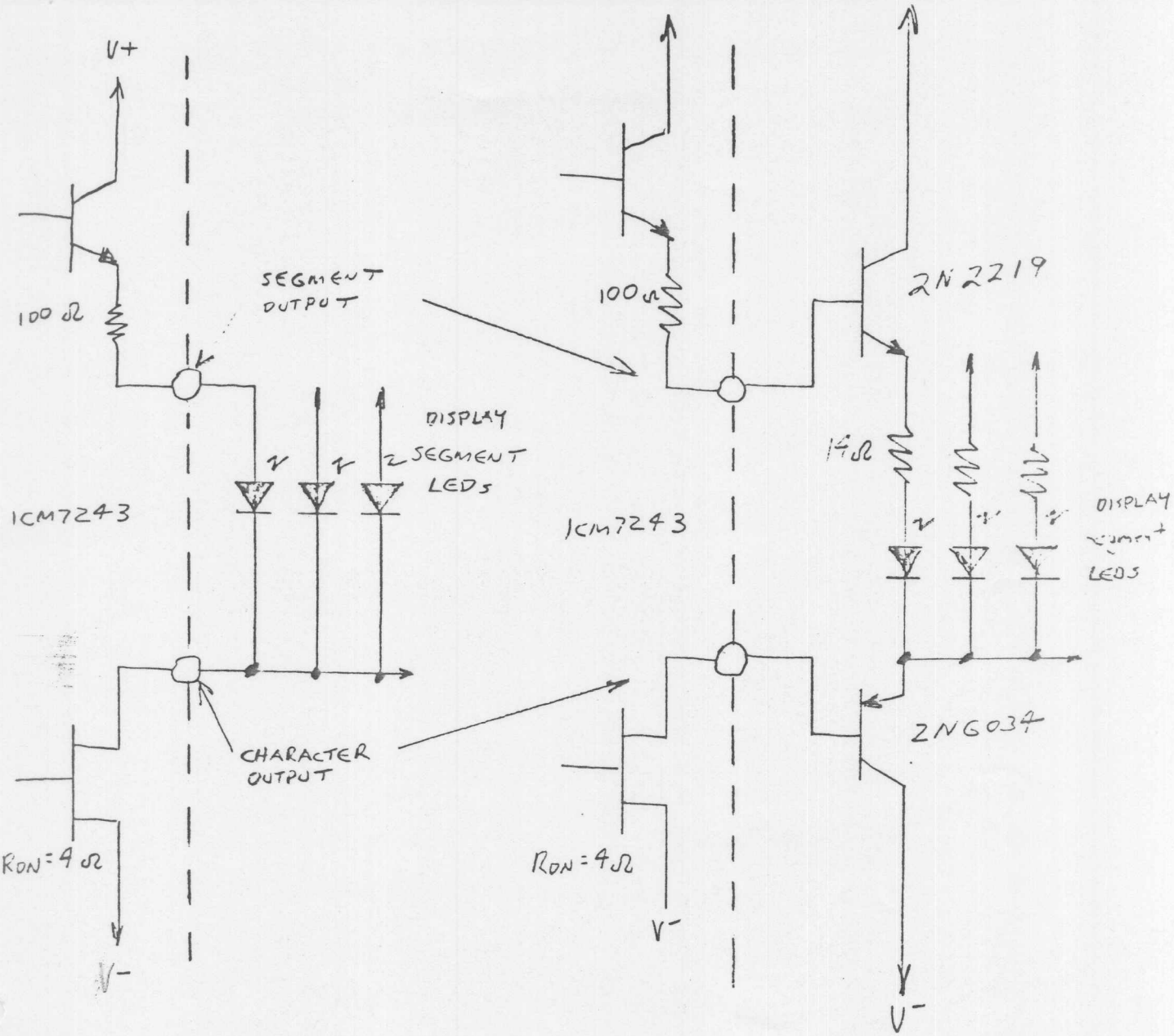
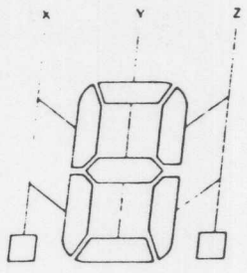


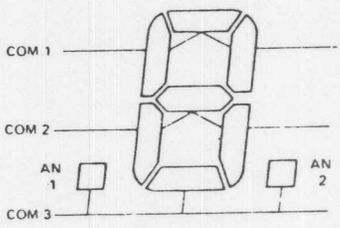
FIGURE 10 DISPLAY CURRENT BOOST CIRCUIT FOR ICM7243

CODE INPUT				DISPLAY OUTPUT D5, D4			
D3	D2	D1	D0	0, 0	0, 1	1, 0	1, 1
0	0	0	0	@	P		0
0	0	0	1	A	Q	!	1
0	0	1	0	B	R	"	2
0	0	1	1	C	S	#	3
0	1	0	0	D	T	$	4
0	1	0	1	E	U	%	5
0	1	1	0	F	V	&	6
0	1	1	1	G	W	'	7
1	0	0	0	H	X	(	8
1	0	0	1	I	Y	)	9
1	0	1	0	J	Z	*	:
1	0	1	1	K	[	+	;
1	1	0	0	L	\	,	<
1	1	0	1	M	]	-	=
1	1	1	0	N	↑	.	>
1	1	1	1	O	←	/	?

DATA DECODING
6 - BIT ASCII → 18 SEGMENT
(ICM7233/34)

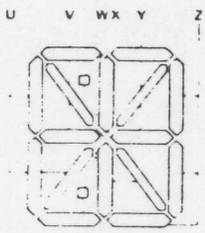


SEGMENT LINE CONNECTIONS

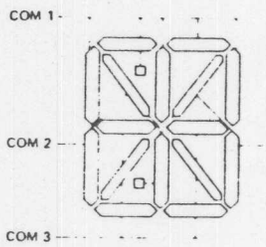


COMMON LINE CONNECTIONS

BOTH ANNUNCIATORS
ON COMMON = 3
(AT BOTTOM OF CHARACTER)

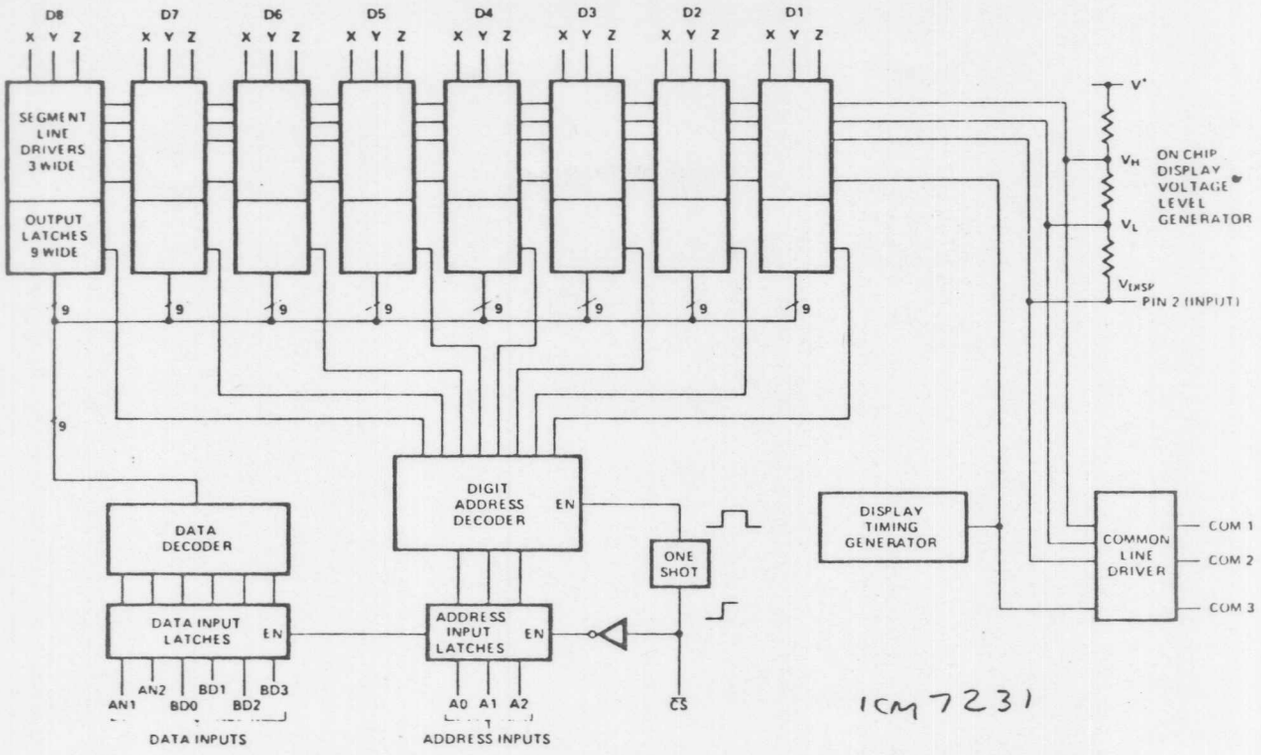


SEGMENT LINE CONNECTIONS



COMMON LINE CONNECTIONS

FIGURE .11 TRIPLEXED LCD CHARACTER LAYOUT AND ASCII CHARACTER SET



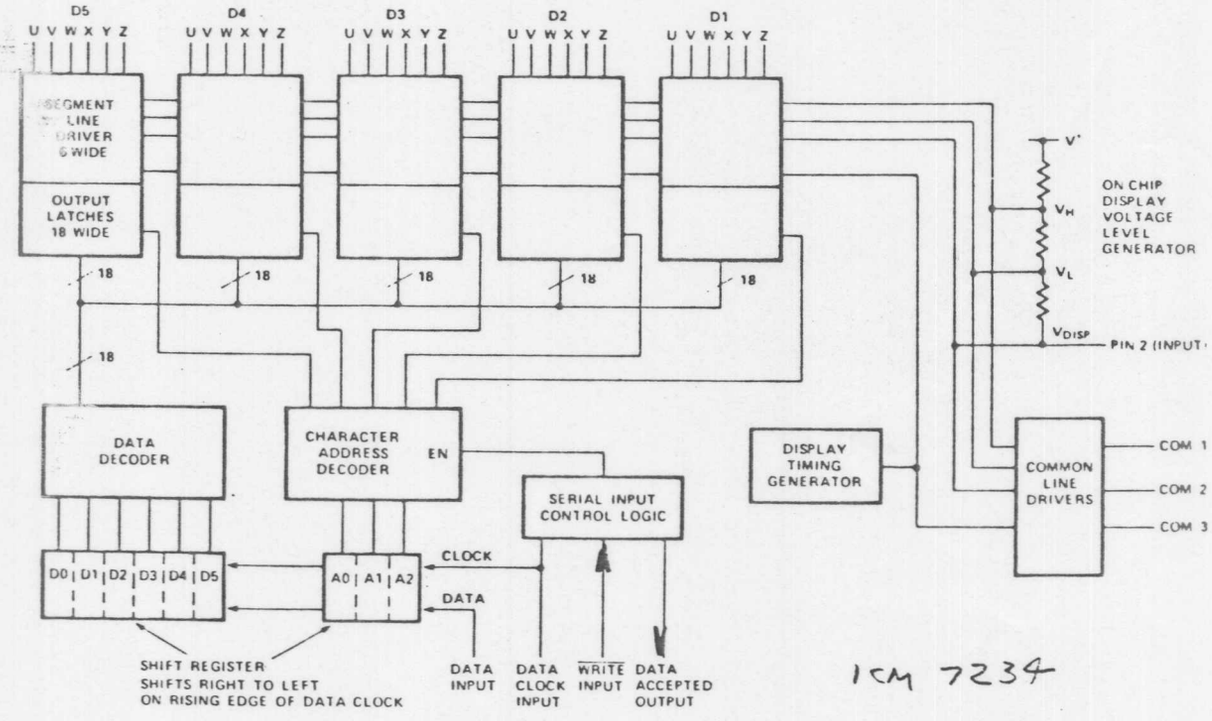


FIGURE 12 ICM7231 AND ICM7234 BLOCK DIAGRAMS

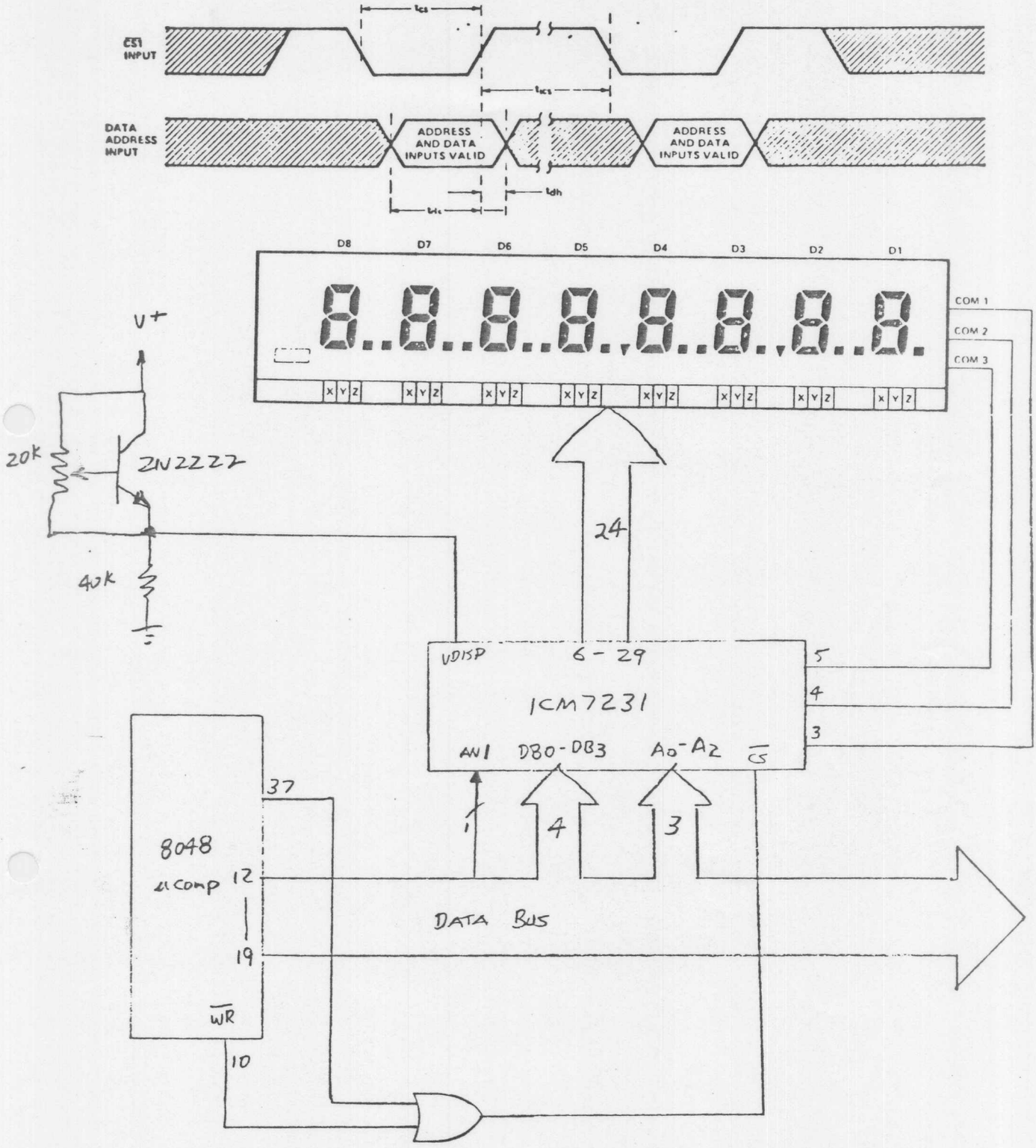


FIGURE 13 EIGHT DIGIT TRIPLEXED LCD MICROCOMPUTER DISPLAY

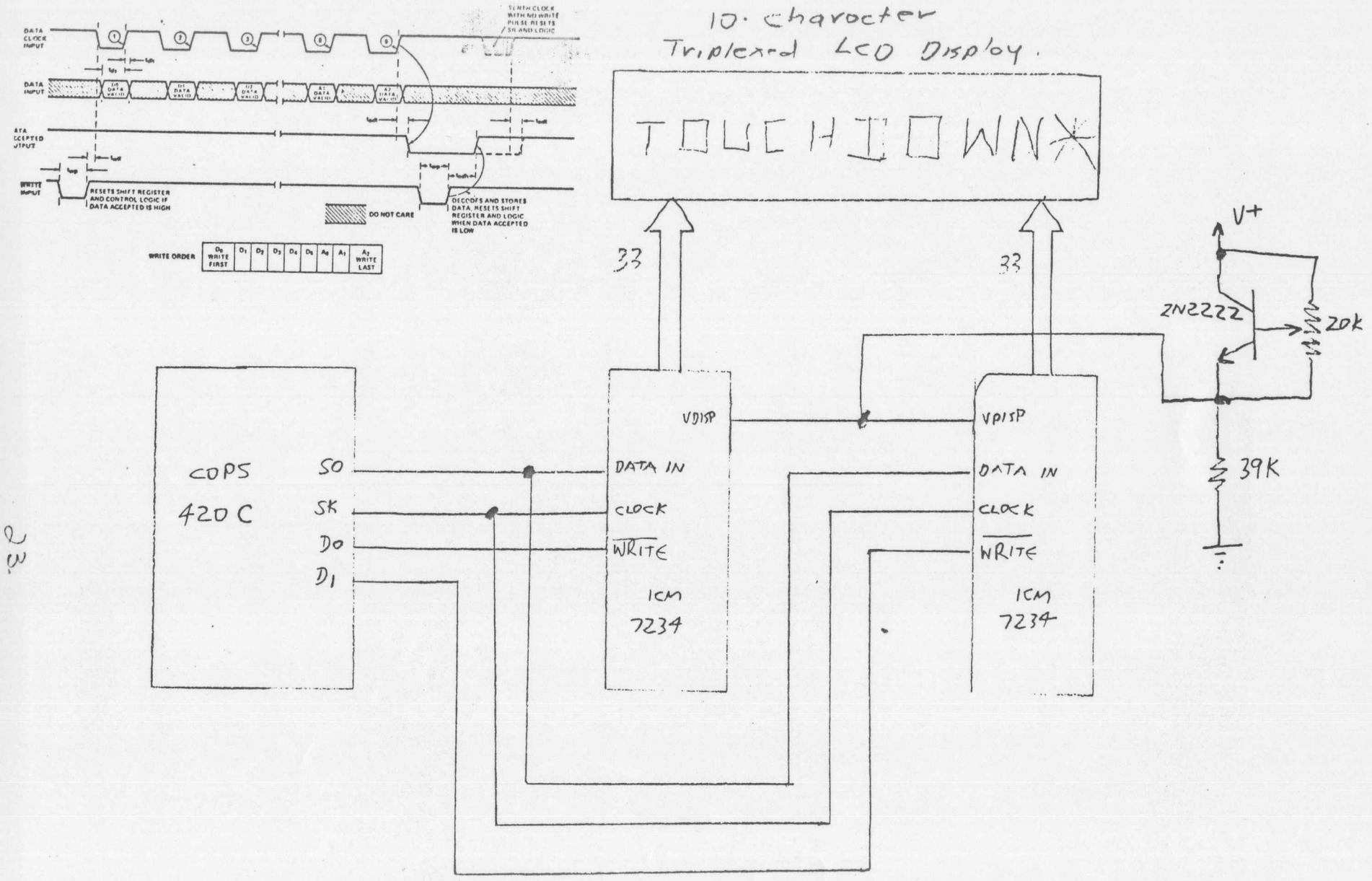


FIGURE 15 10 CHARACTER ALPHANUMERIC TRIPLEXED LCD DISPLAY WITH SERIAL MICROCOMPUTER INTERFACE

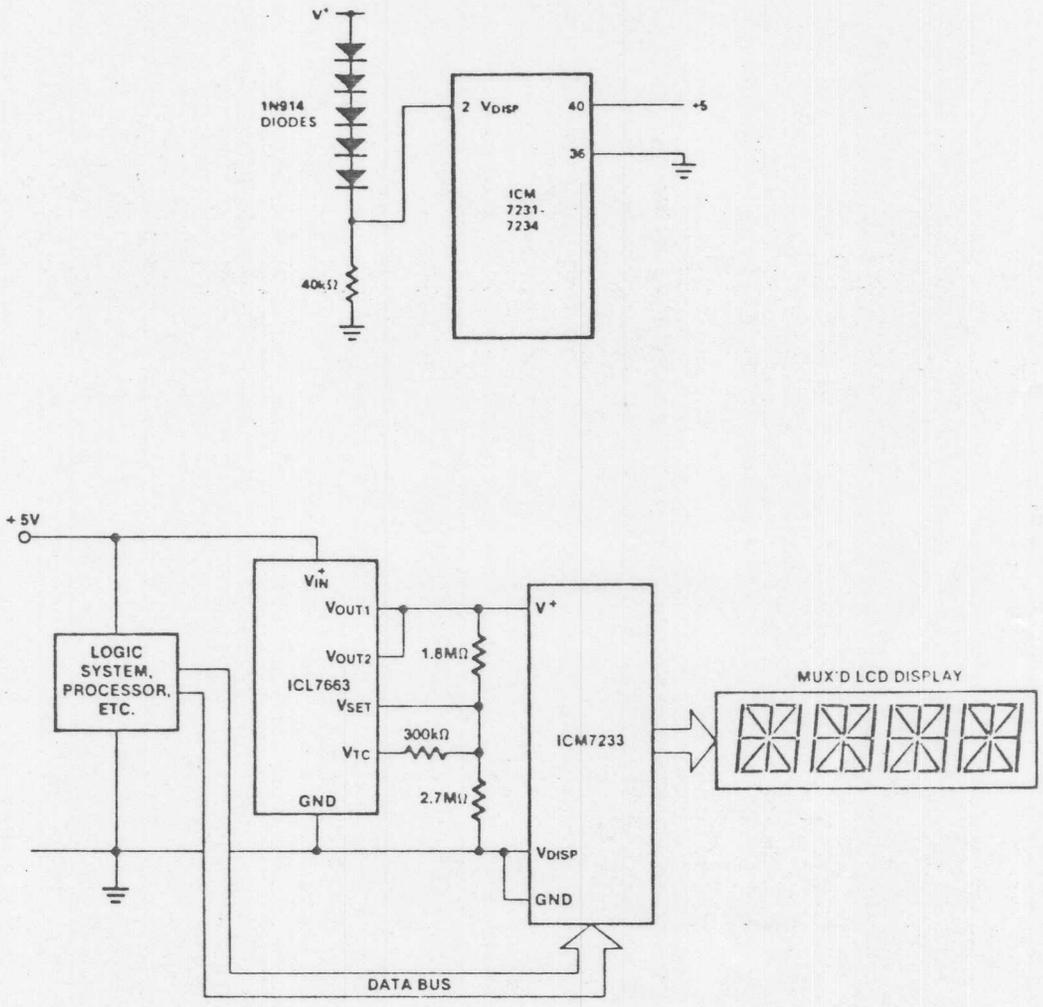


FIGURE 14 TRIPLEXED LCD TEMPCO COMPENSATION CIRCUITS

The noise performance of the ICL7106/7/9 family is controlled by the noise trapped on the auto-zero capacitor at the beginning of the integrate phase. This noise depends (in a complicated way) on the input noise of the buffer amplifier. If the built-in buffer is replaced by a low-noise op amp, the noise performance could be improved, especially if gain can be introduced into this buffer, as can be done with the two-chip devices.

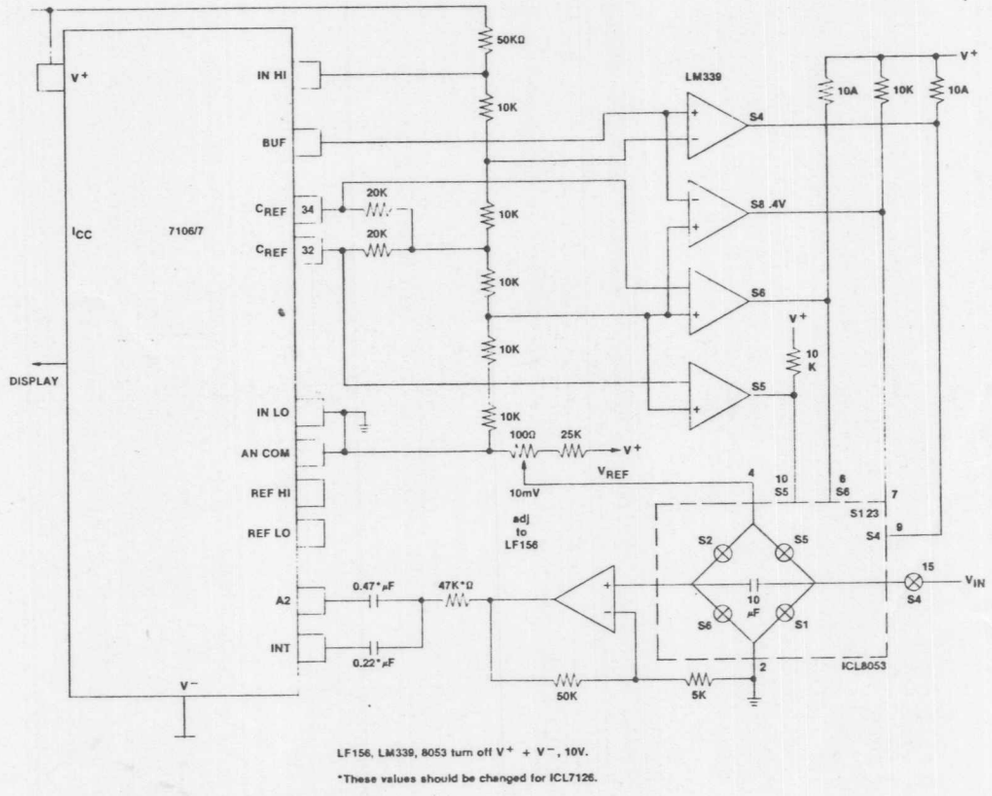


Figure 23: Low Noise Preamp Circuit.

Figure 23 shows a way of doing this, the main losses being in higher input current and the lack of a true differential input. The switch network of the original is replaced by an ICL8053 driven in synchronism with the internal counter by using the original switch network-buffer combination, fed by resistive dividers, and a quad comparator to detect the various phases as shown.

Lots of people ask about an LCD version of the ICM7216/7226 family. Figure 24 here shows how to do this, using our new Triplex Multiplexed LCD Drivers.

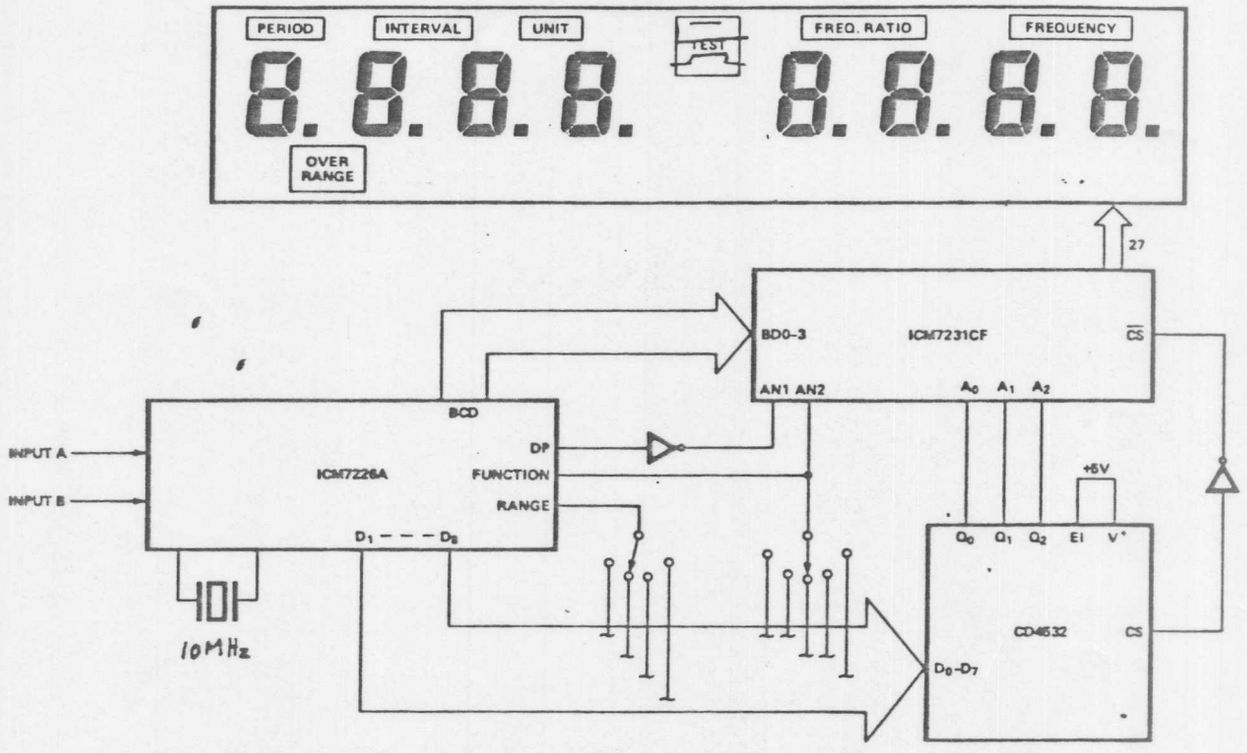


Figure 24. 10 MHz Frequency/Period Pointer with LCD Display. The annunciator show function and the decimal points indicate the range of the current operation. The system can be efficiently battery operated.